Symmetry, Proportion and Scale:
Tools for the Jacquard Designer and Weaver of Silk Velvet

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Abstract

As a weaver I use the principles of symmetry, proportion and scale to design and weave my silk velvets on a Jacquard loom.

Introduction

The design power of the Jacquard is attracting more and more weavers. We want to design larger motifs and images with greater detail, smoother lines, and finer grain. Understanding symmetry, proportion and scale makes us better designers. We are discovering the power of math.

Cloth is Woven Structure

Cloth is woven structure; an interlacement of the warp, the threads stretched on the loom, and the weft, the threads that are inserted by the weaver. Whether on a low-tech backstrap loom or a computerized Jacquard, when a weft meets a warp, it must go either over or under. This fundamental binary decision is weaving. The most basic structure is plain weave, the familiar over-under of burlap. Floats create all the other woven textures and patterns. A float occurs when a warp or weft skips over or under more than one. Plain weave can be done by hand. The weaver lifts alternately the odd warps, passes a weft, and then lifts the evens for the next weft. The fabric builds weft by weft. This process can be done by hand manipulation, but for speed and sanity the weaver employs a loom.

The Standard Loom

On a standard loom each warp is threaded through the eye of one wire heddle. The heddles are mounted on frames. When a frame lifts, all the warps on it move as a set and form a plane above the weft. In plain weave only two frames are needed: one lifts the odd warps and one, the even warps.

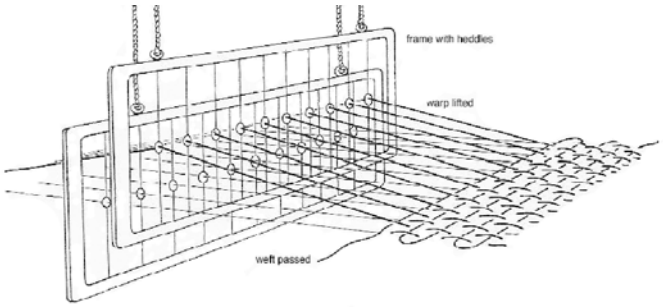

Figure 1: Diagram of a standard loom with warps, wefts, frames, and heddles

With four frames the possibilities increase dramatically. Frames can lift as singles or pairs or triples: there are 14 combinations. Looms come with 4, 8, 12, 16, 24 or 32 frames. More are feasible but impractical. The bulk of frames and the pedals that operate them become unwieldy. The weaver plays the loom like an organ using less than 20 pedals to make the lift combinations. The standard loom can make sound cloth, rich in texture and pattern, but for larger patterns and images another tool is needed.

The Jacquard Loom

The Jacquard loom uses a set of perforated cards to program the weaving. Each card makes every warp take a position above or below for the passing weft. Each warp is threaded through a heddle, but the heddles are not in frames. Each dangles by a cord from a hook and moves independently. Each hook receives instruction from a particular spot on the card: a 100-hook Jacquard has a card with 100 spots. The cards are laced in a chain. One by one they fall onto the cylinder and are read by a bank of needles. When a needle enters a perforation, the warp lifts: when the needle is held back because there is no hole, the warp stays down. The design emerges weft-by-weft, card-by-card. Securing the last card to the first makes a continuous loop, and the design repeats. Jacquards come with 100, 200 or 400 hooks: Vicenzi or Verdol mechanisms have more than 1,000.

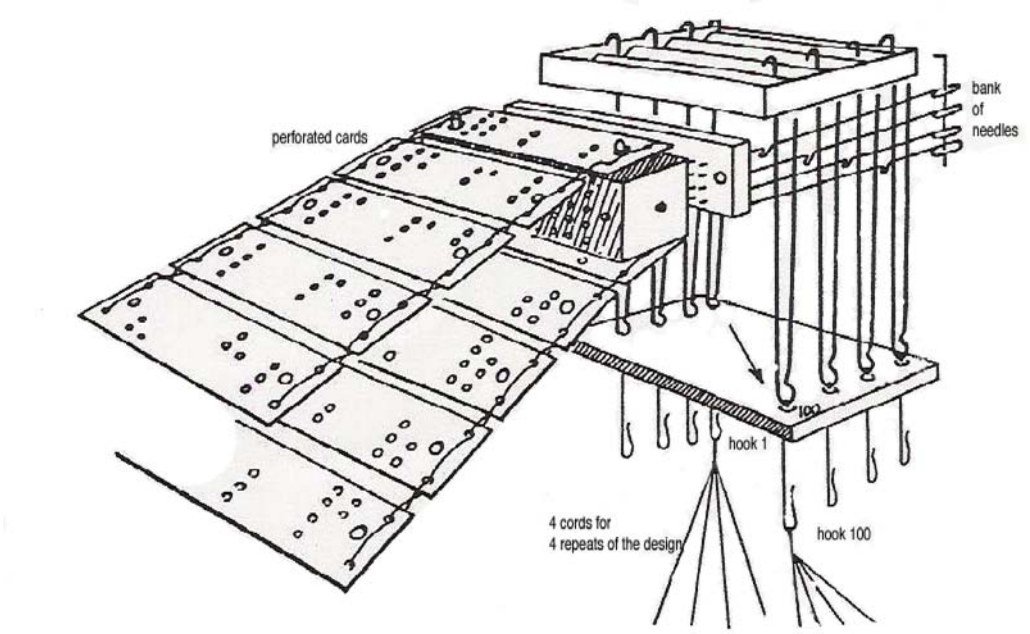

Figure 2: the Jacquard system

The number of hooks limits the size of the design but not the size of the fabric. The Jacquard loom uses symmetry strategies based on translation and/or reflection to increase design potential. Generally each hook operates more than one heddle. For bilateral reflection each hook has two cords that govern matching spots on either side of the central vertical axis. For four repeats in translation, each hook has four cords, thus four heddles work matching spots in the design. It is far easier to adapt the design to fit the loom's mounting than it is to change the hook, cords and heddles. Clever designers use the loom's symmetries to maximize design power.

Knowing the mounting symmetry, the designer makes a sketch and translates it onto point paper, a special graph paper. The number of hooks dictates the number of squares wide the design must be. The

height of the design equals the number of cards or wefts needed to weave one design repeat. The point paper reflects the proportion of warps to wefts. Tall rectangles mean the warps are denser than the wefts: squat rectangles mean the wefts are denser. Once the design is on point paper, the weaver knows where to perforate the card reading the point paper line by line.

The Woven Structure of Velvet

Plain velvet needs two sets of warps: the ground makes the foundation of the cloth, and the pile, the tufted surface. The piles are lifted over a slim brass velvet wire and interlaced to the ground with three or four wefts. After three velvet wires have been woven in, the first can be cut out by drawing a fine blade down the miniscule groove in the velvet wire or simply withdrawing it for the tiny loops of uncut pile.

In figured velvets areas of pile contrast areas without pile. Because the design uses piles differently, they must be independent units free to lift when needed. So each pile unit is wound separately on a bobbin, held in a rack below the loom, and unwinds individually on command.

The figured velvets I design and weave at the Foundation Lisio in Florence, Italy, are done on a loom with 8 frames for the ground and a 400-hook Jacquard to raise the piles. The loom is mounted two repeats in translation. Jacquard velvet looms are mounted with either two or four repeats in translation or one repeat in reflection for grand, opulent designs. The 400 hooks have two cords that controls the 800 pile bobbins. However, on the loom that wove my *Girandola* design, I had the design option to lift a red or a blue pile, or no pile at all. The loom was threaded 2 grounds, 1 red pile, 1 blue pile, 2 grounds.

The point paper was 400 squares wide divided into 25 columns of 8. I read the point paper and punched all the red pile lifts, then I reread that same line and punched all blue pile lifts, so on every card the left side controls the red bobbins and a right side, the blue. The ground shows in areas without pile.

My point paper was a grid of tall rectangles, not squares. The proportion closely represents the ratio of warp piles to velvet wires used. Taking a lens I counted 14 piles per centimeter in the warp to 11 rows in the weft. 11 divided by 14 equals .7857. In 8/10 point paper the proportion was 0.8. My design was not distorted, elongated or squashed.

My design started with a simple right triangle marked with a ‘Y’. I rotated that motif two quarter-turns and fitted that triangle into the original triangle to make a square. Then I rotated the square a quarter turn and made the second square and then repeated them to make a design four squares wide. Above each square I drew the opposite square. A pinwheel emerged.

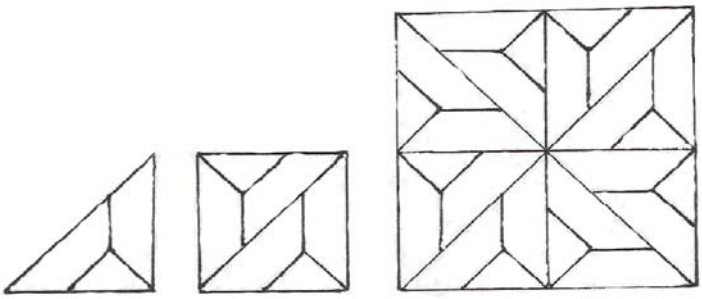

Figure 3: generating the design motifs and matrix for *Girandola*

Next I played with color. I wanted my design to have a balance between the red and blue pile so 16 trapezoids are red and 16, blue. Value is a key factor in velvet design: uncut pile appears light and pearly, cut pile, dark and deep. *Girandola* has 32 trapezoids, 9 are cut, 11 are uncut, and 12 are partially cut. To achieve a value midway between the light and dark, I must actually cut far less pile than 50%. Through trial and error I have discovered that alternating rows of uncut with rows of 2 cut, 2 uncut, does the job. The voids, areas without pile where the ground shows appear as 16 isosceles triangles.

Girandola is a tessellation that plays with color symmetry. I sketched 6 versions placing the red and blue pile in different areas, changing the areas of pile and ground. In my final version I chose to repeat the pinwheel twice but change the areas of cut pile: the left pinwheel emphasizes the horizontal and the right the vertical. Because of its shape, it seems to turn. This velvet design is a metaphor for my daily life. I do not see myself as a juggler where I attend to a blur of tasks serially, but as the plate spinner in the circus who runs frantically but purposefully from plate to plate giving each a bit of energy to keep it poised, precariously turning. For me velvet is worth every bit of the effort. The Jacquard allows me design freedom to play with symmetry, proportion and scale at my heart's content.

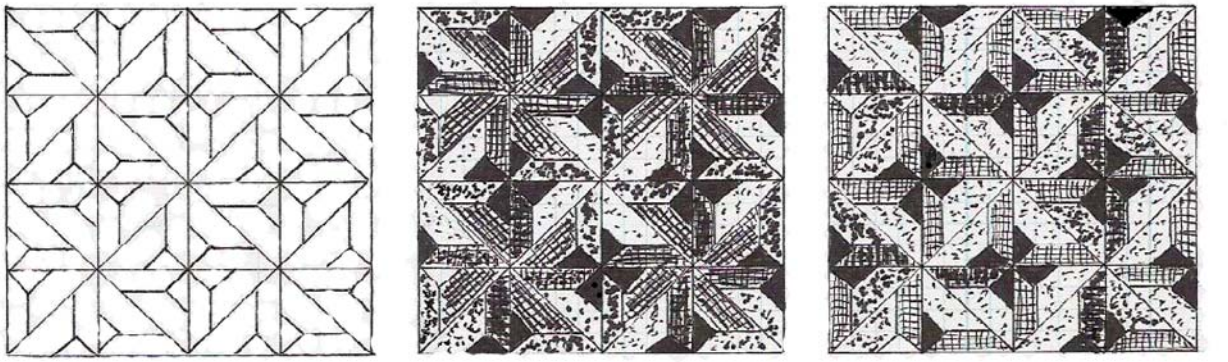

Figure 4: *Girandola* design matrix, color symmetry variations
cross-hatched=blue; dotted=red; black solids=areas of ground, voids without pile

References

Puliti, Mario. *Elementi fondamentali di disegno tecnico tessile.* Firenze: Editrice Milano-Roma. Figure 1 & 2 are adapted from this text

Washburn, Dorothy K. and Donald W. Crow. *Symmetries of Culture: Theory and Practice of Plane Pattern Analysis*. Seattle: University of Washington Press, 1988.